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Heavy metal determination in selected local and foreign food seasonings sold in markets within Enugu metropolis and their health risk potentials

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ABSTRACT

Studies were carried out to evaluate the heavy metal levels in the selected local and foreign food seasonings sold in markets within Enugu metropolis and their health risk potentials to the adult population, using standard analytical procedures and instrumentation. The purchased samples were wet digested and analyzed for heavy metal presence using atomic absorption spectrophotometer (AAS) and subsequently subjected to statistical analysis. The mean range for Pb in the local food seasoning (ogiri igbo and ogiri okpei) samples was 0.157 - 0.241 µg/g and 0.183 – 0.361 µg/g in the foreign food seasoning (knorr maggi, star maggi and royco maggi) samples. 1.892 – 2.534 µg/g was the mean range for Cu in the local food seasoning samples and 1.137 – 1.334 µg/g in the foreign food seasoning samples. 0.122 – 0.130 µg/g was the mean range for Cd in the local food seasoning samples and 0.108 -0.252 µg/g in the foreign food samples. The mean values of the investigated metals in the studied seasoning samples differed significantly. The studied metals were at non-toxic levels in both the local and foreign food seasoning samples. The estimated daily intakes (EDI) for the investigated metals by the adult population that consumes the studied food seasonings in their daily diets were within the provisional maximum tolerable daily intakes (PMTDI) established for the metals. Constant evaluation and monitoring of the levels of food toxicants such as heavy metals by food regulatory authorities in particularly food seasonings consumed daily by the people is critical to safeguarding the health of the people and maximizing the health benefits derivable from the consumption of the seasonings.

Keywords: Local food seasonings, foreign food seasonings, Heavy metals and estimated daily intake.

1. INTRODUCTION

According to WHO, (2014), food seasonings are substances added to food to maintain, enhance or improve the freshness, taste, appearance or other sensory

qualities of the food. Oladoye and Jegede, (2016) and Okeke et al., (2018) defined food seasonings as spices comprising of dried seeds, fruit bulbs, vegetables and dried small size aquatic animals, primarily used for flavouring, colouring and sweetening food. Food seasonings as flavouring agents are a combination of several components including salt.

According to Muhammad et al., (2011), food seasonings can be used to replace common salt in different food preparations at both commercial and domestic scale. Virtually every household in all human society apply seasonings, either in locally packaged form or foreign packaged form to enhance the taste, flavour, appearance and nutritive qualities of different delicacies. In other words, apart from increasing the sensory qualities of foods, food seasonings equally increase the mineral content of foods.

According to Mohammed et al., (2018) and Okeke et al., (2018), food seasonings contain bio active agents that have numerous health benefits. Mohammed et al., (2018) and Ifesan et al., (2019) stated that local food seasonings such as ogiri igbo (*Parkia biglobosa*) and ogiri okpei (*Ricinus communis*) helps to promote digestion, boost immune system, fight colon cancer, improve heart health, treat tooth ache, enhance brain performance and treat oedema. The foreign food seasonings such as maggi, protects against iron deficiency, increases essential elements supply for enzymatic activity, however, at excessive dosage could cause heart attack, fatigue, vomiting, headache and even stroke (Oladoye and Jegede, 2016; Okeke et al., 2018).

Ogiri igbo and ogiri okpei are fermented food seasonings that form important food addition in the preparation of special African soups and delicacies for both private and commercial purposes, whereas maggi cubes are applied in the preparation of common African soups and staple foods. Although these food seasonings are usually rich in mineral elements such as potassium, calcium, magnesium, sodium and zinc among others, however, equally contain heavy metals as a result of anthropogenic contamination during processing, packaging and storage (Muhammad et al., 2011; Asomugha et al., 2016).

For instance, local seasonings such as ogiri igbo and ogiri okpei could harbor heavy metals from the seed plant (if harvested from a heavy metal polluted soil), water used during the fermentation, processing, packaging, storage and even the method of handling of the food seasonings at the point of sale. Equally, the anthropogenic origin of the material composition, processing, packaging and storage of the foreign seasonings such as maggi cubes has contributed to their contamination with heavy metals (Krepjcio et al., 2007).

According to Alkorta et al., (2014), Okeke and Okeke, (2015), Okeke et al., (2018), Okeke et al., (2023), Markmanuel et al., (2023) and Adetola et al., (2023), heavy metals are the most dangerous substances in the environment due to their level of durability, toxicity, non-biodegradability, bioaccumulation and long biological half–lives. Mathews-Amume and Kakulu, (2013), Aniobi et al., (2019) and Okeke et al., (2021), stated that prolonged consumption of heavy metals through food materials may lead to its chronic accumulation in the liver and kidney of humans, thereby causing the disruption of numerous biochemical processes. Based on the health safety concerns associated with the use of food seasonings, food regulatory bodies have provided regulations on the levels of food contaminants in food additives.

Ogiri igbo, ogiri okpei and maggi cubes are food seasonings for everyday use in food preparation to flavour and enrich the taste of foods in all human societies. These everyday food seasonings are required to be free or at least at safe levels of contaminants such as heavy metals in order to maximize the health and nutrient benefits by the food consumers (Racheal et al., 2023; Johnson et al., 2022). Inhabitants within Enugu metropolis consumes these seasonings daily in their food delicacies, apart from enjoying the pleasant taste and flavour that their use provides, could get unduly exposed to heavy metals, which is of a critical concern. Hence, this study was carried out to evaluate the heavy metal levels in selected everyday food seasonings consumed within Enugu metropolis and the health implication of the daily intake of the metals on the adult population.

2. MATERIALS AND METHODS

Sample collection and preparation

The selected local food seasonings (ogiri igbo (*Parkia biglobosa*) and ogiri okpei (*Ricinus communis*)) and foreign seasonings (knorr maggi, star maggi and royco maggi) were purchased ten (10) pieces each from markets within Enugu metropolis. The samples were unwrapped and dried in air, followed by oven drying at 80^{o} C until a constant weight was obtained. The oven-dried samples were ground with a ceramic mortar and pestle into fine particles and stored separately into well labeled polyethene containers prior to analysis.

Sample Digestion

About I g of the dried powdered sample was weighed into 250ml beaker and subsequently mixed with 5ml of Conc. HNO_3 and $HClO_4$ at a ratio of 3:2. The digestion temperature was 150^{o}C which lasted for 4hrs. The digestion was completed at the sight of white fumes. The digests were allowed to cool and subsequently diluted with de-ionized water (to avoid chemical attack of the

filter paper) and filtered into 50ml volumetric flask and made up to mark with de-ionized water. Each of the samples went through triplicate digestion procedure together with reagent and was kept in refrigerator prior to analysis.

The samples were analyzed for the presence of Pb, Cu and Cd using Hitachi Z-5000 flame atomic absorption spectrophotometer (AAS), fueled with acetylene gas. Quality control measures were employed to reduce the risk of metal contamination and ensure the reliability of the results.

Statistical analysis

The data obtained were expressed in mean ± standard deviation and subjected to one way analysis of variance (ANOVA) at 5% confidence level using IBM SPSS 23.0.

Human health risk assessment

The health risk assessment of the daily intake of the investigated heavy metals through consumption of diets prepared with food seasonings by the adult population within Enugu metropolis was estimated using the equation;

$$EDI = \frac{C \times AC}{bw}$$

Where, EDI represents estimated daily intake, C equals to concentration (µg/g) of the heavy metals in the food seasonings, Ac equals to the average dry weight (about 14g) of the food seasonings consumed daily by the population, which was obtained using questionnaire and bw equals to the average adult bodyweight (60kg).

3. RESULTS AND DISCUSSION

Lead

Table 1 shows that the mean Pb values in the ogiri igbo, ogiri okpei, knorr maggi, star maggi and royco maggi samples were 0.241±0.061, 0.157±0.044, 0.183±0.041, 0.361±0.023 and 0.279±0.025 µg/g respectively. The mean Pb values decreased in the food seasoning samples in the following order; star maggi > royco maggi > ogiri igbo > knorr mgagi > ogiri okpei (Figure 1).

Table 1 Mean heavy metal concentrations in the food seasoning samples sold in markets within Enugu metropolis

Sample / Metal (µg/g)	Ogiri igbo	Ogiri okpei	Knorr maggi	Star maggi	Royco maggi	F test P value	WHO, (2014) STD
Pb	0.241±0.061	0.157±0.044	0.183±0.041	0.361±0.023	0.279±0.025	0.02	0.5
Cu	2.534±0.211	1.892±0.313	1.334±0.541	1.137±0.171	1.251±0.326	0.01	10
Cd	0.130±0.052	0.122±0.011	0.168±0.024	0.252±0.031	0.108±0.011	0.02	0.5

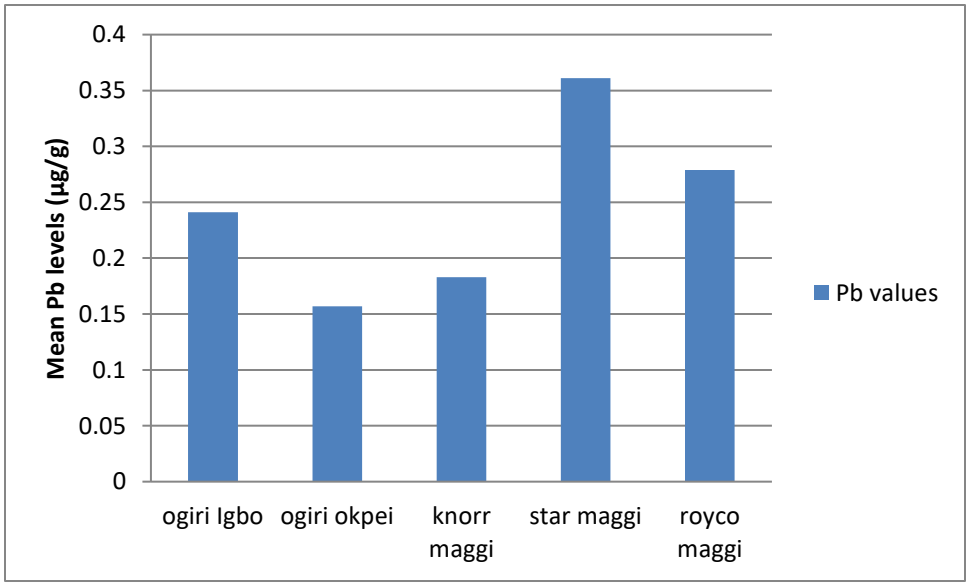

Figure 1 Bar chart representation of the mean Pb values in the investigated food seasoning samples sold in markets within Enugu metropolis

The mean Pb values in the studied food seasoning samples were statistically significant but within its WHO recommended permissible limits (Table 1). It is instructive to note that the mean Pb values in the foreign food seasoning samples such as star maggi and royco maggi was higher than it was in the local seasoning samples (ogiri igbo and ogiri okpei). One would have thought otherwise prior to the analysis, going by the nature of our environment and the near unhygienic processes employed by the local processors in processing, storing and packaging the seasonings. This therefore highlights the ubiquitous nature of heavy metals in human environment and which indicates that extra care must be taken in sourcing food materials and their processing into edible food products to ensure their minimal contamination with heavy metals.

Gaya and Ikechukwu, (2016) reported a mean Pb range of 2.833 - 4.167 μg/g in the leafy spices sold in Abubakar Rimi market, Kano metropolis, than was gotten for the metal in the food seasoning samples. Environmental factors in the sourcing and handling of the food seasoning materials could be a possible reason for the variation in the compared studies. Muhammad et al., (2011), reported a lower mean Pb range of 0.02 – 0.03 μg/g in the food seasonings (royco, knorr and onga) sold in Minna Central market, Niger State, than what was obtained for the metal in the investigated foreign food seasoning samples.

Also, Okeke et al., (2016), reported a comparable mean Pb range of 0.097 – 0.171 μg/g in the leafy spices sold in Emene marked, Enugu State, with what was gotten for the metal in the ogiri okpei and knorr maggi samples. According to Okeke et al., (2018), Aniobi et al., (2019), Çoban et al., (2021) and Okeke et al., (2021), lead is a significant heavy metal toxicant that affects the bones, brain, blood, kidney, liver and thyroid gland on prolonged exposure. They equally observed that lead toxicity has been established to cause muscoskeletal, renal, ocular, neurological, immunological, reproductive and developmental defects.

Copper

Table 1 shows that the mean Cu levels in the ogiri igbo, ogiri okpei, knorr maggi, star maggi and royco maggi sample were 2.534±0.211, 1.892±0.313, 1.334±0.541, 1.137±0.171 and 1.251±0.326 μg/g respectively. The food seasoning samples had mean Cu levels in the following decreasing order; ogiri igbo > ogiri okpei > knorr maggi > royco maggi > star maggi (Figure 2).

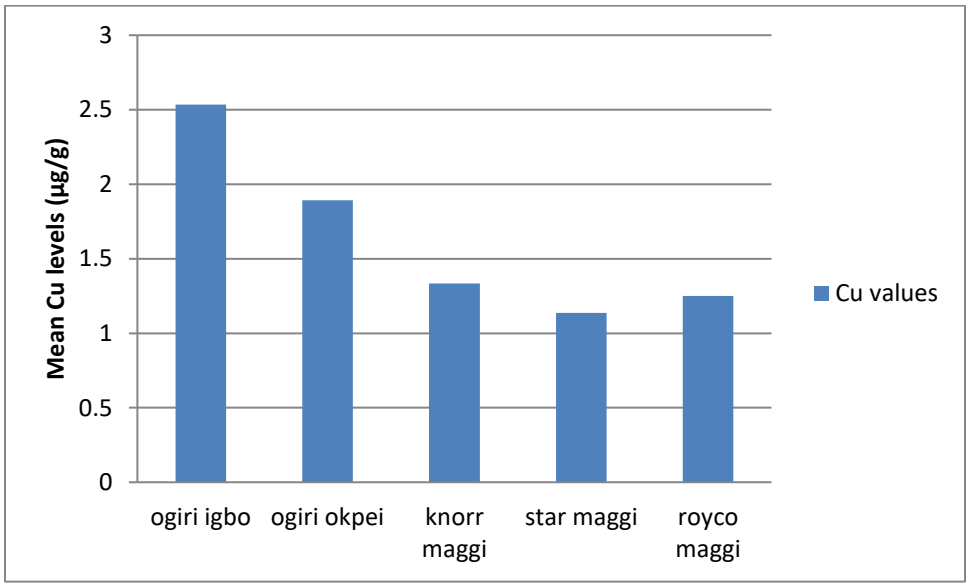

Figure 2 Bar chart representation of the mean Cu values in the investigated food seasoning samples sold in markets within Enugu metropolis

From Table 1, it could be seen that the mean Cu levels in the investigated seasonings were statistically significant and equally within the recommended threshold limits. From Table 1 was that the local seasoning (ogiri igbo and ogiri okpei) samples had higher mean Cu levels than the investigated foreign seasoning (knorr maggi, star maggi and royco maggi) samples. This observation therefore indicates the richness and nutritive value derived from the consumption of local seasonings and hence encourages its essentiality in the preparation of specific foods. Okeke et al., (2016) reported a lower mean Cu range of 0.147 -0.401 μg/g in the leafy spices sold in Emene market, Enugu State, than what this study got for the metal in the food seasoning samples.

Gaya and Ikechukwu, (2016) obtained a higher mean Cu range of 6.112 – 9.453 μg/g in the leafy spices sold in Abubakar Rimi market, Kano metropolis, than what was reported for Cu in the studied food seasoning samples. According to Radwan and Salama, (2015), Ezeh et al., (2018), Okeke et al., (2018) and Aniobi et al., (2019), copper is an essential micro element, that serves as an anti-

oxidant and plays a significant role in bone formation and skeletal mineralization. However, Turnlund, (1998), Okeke and Okeke, (2015) and Okeke et al., (2021) stated that copper poisoning in man could lead to diarrhea, nausea, liver and kidney damage.

Cadmium

According to FSAI, (2009), Ezeh et al., (2018) and Aniobi et al., (2019), cadmium is present at low amounts in most foods, with commodities such as cereals, fruits, vegetables, meat and fish, accounting for its largest contribution to dietary exposure due to the fact that they are the foodstuffs mostly consumed. From Table 1, ogiri igbo, ogiri okpei, knorr maggi, star maggi and royco maggi samples had mean Cd levels of 0.130±0.052, 0.122± 0.011, 0.168± 0.024, 0.252± 0.031 and 0.108± 0.011 µg/g respectively. The mean Cd values in the seasoning samples differed significantly, however, were within the recommended threshold limits for a food substance meant for human consumption. The food seasoning samples had mean Cd values in the following decreasing order; star maggi > knorr maggi > ogiri igbo > ogiri okpei > royco maggi (Figure 3).

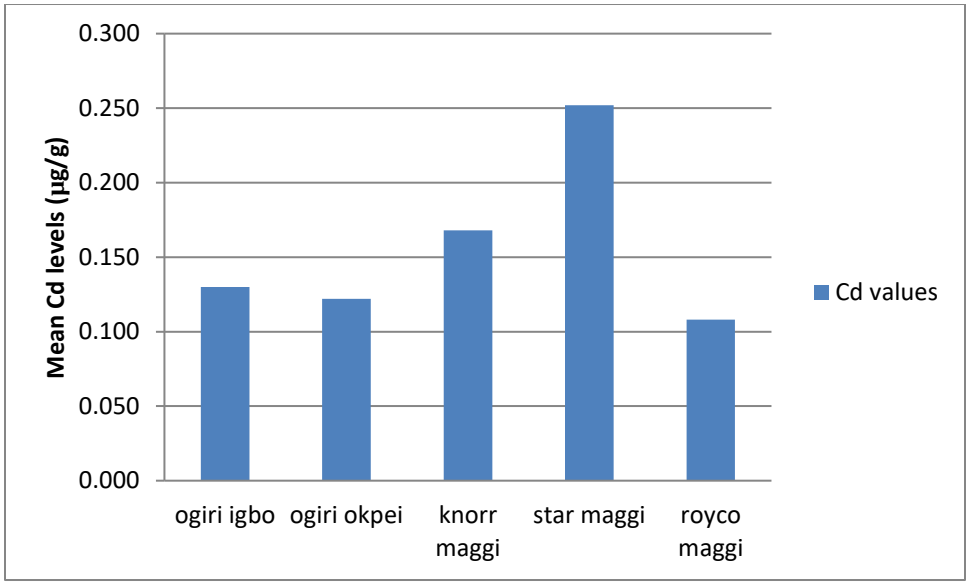

Figure 3 Bar chart representation of the mean Cd values in the investigated food seasoning samples sold in markets within Enugu metropolis

Muhammed et al., (2011), reported a lower mean Cd range of 0.02 – 0.03 µg/g in the seasonings (royco, onga and knorr) samples sold in Minna Central market, Niger State, than what this study got for the metal in the studied food seasoning samples. Gaya and Ikechukwu, (2016), reported a higher mean Cd range of 5.317 – 6.383 µg/g in the bulb (garlic, onion and shallot) spices sold in Abubakar Rimi market, Kano metropolis, than what was obtained for Cd in the studied food seasoning samples. Okeke et al., (2018) and Okeke et al., (2021), reported that organs such as the liver, placenta, kidney, lungs, brain and bones can be adversely affected by cadmium exposure.

Human health risk assessment

From Table 2, it was observed that the estimated daily intake (EDI) of the investigated heavy metals by the adult population (with average body weight of 60 kg), who consumes an estimated (from questionnaire) 14g of the food seasoning samples were within the provisional maximum tolerable daily intakes (PMTDI) for the metals as established by EFSA, (2012) and WHO, (2014). This is a spirit lifting observation for the general population and in particular, the adult population living within Enugu metropolis, because the studied food seasonings form a significant application in their daily meal preparations. The estimated daily intake of the investigated heavy metals by the adult population decreased in the following order; Cu > Pb > Cd.

Table 2 Estimated daily intake (μg/kg bw/day) of the studied metals by the adult population, living within Enugu metropolis, who consumes the food seasonings

Metal / Sample	Pb	Cu	Cd
Ogiri igbo	0.06	0.61	0.03
Ogiri okpei	0.04	0.42	0.03
Knorr maggi	0.04	0.31	0.04
Star maggi	0.08	0.26	0.06
Royco maggi	0.07	0.29	0.03
PMTDI (WHO, 2014; EFSA, 2012)	3.60	70.00	0.83

4. CONCLUSION

The investigated heavy metals (Pb, Cu and Cd) were present in both the local (ogiri igbo and ogiri okpei) and foreign (knorr maggi, star maggi and royco maggi) samples at non-toxic levels. Each of the local food seasoning samples had a higher mean concentration of the studied essential trace (Cu) element than the foreign food seasoning samples and the reverse for the heavy metals (Pb and Cd). The estimated daily intakes of the studied metals by the adult population living within Enugu metropolis, were within the recommended provisional maximum tolerable daily intakes and therefore this adult population, who consumes the investigated food seasonings daily in their meals are not at food or health risk from the metals.

Informed consent

Not applicable.

Ethical approval

Not applicable.

Conflicts of interests

The authors declare that there are no conflicts of interests.

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The study has not received any external funding.

Data and materials availability

All data associated with this study are present in the paper.

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